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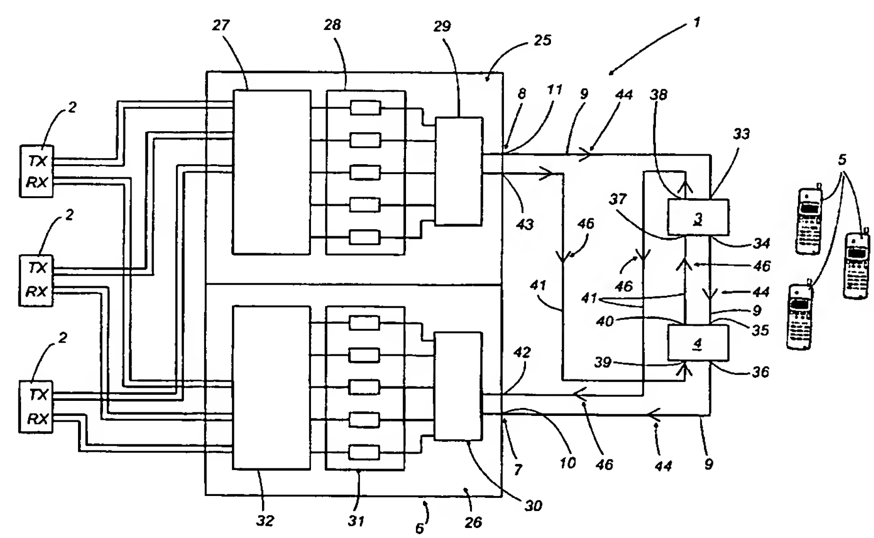
(54) Title: COMMUNICATIONS NETWORK, IN PARTICULAR FOR TELEPHONY, WITH BASE STATIONS CONNECTED TO REMOTE TRANSCEIVER UNITS



(57) Abstract: A communications network, in particular for telephony, comprises at least one operator (2), a plurality of remote units (3, 4) for exchanging signals with mobile terminals (5) and an interface unit (6) for controlling the data traffic between the operator (2) and the remote units (3, 4). The interface unit (6) is connected to the remote units (3, 4) by a first transmission support (9), in which the main signal (44) propagates. The main signal (44) is divided into a plurality of secondary signals (45), each identified by a preset parameter value. Each remote unit (3, 4) is designed to process at least one secondary signal (45a) selected from amongst the secondary signals (45) into which the main signal (44) is divided. The secondary signal (45a) is identified by the remote unit (3, 4) according to the above-mentioned preset parameter value.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Description

COMMUNICATIONS NETWORK, IN PARTICULAR FOR TELEPHONY, WITH BASE STATIONS CONNECTED TO REMOTE TRANSCEIVER UNITS.

Technical Field

The present invention relates to a communications network, in particular for telephony.

Background Art

As is known, at present in the communications systems for cellular telephony the mobile terminals (cellular phones) dialog by means of radio frequencies with the Base Station Systems, hereinafter referred to with the abbreviation BSS (Base Station System), which are connected to the Control Centres, hereinafter referred to with the abbreviation MSC (Mobile Services Switching Centre). The latter allow a connection both to other MSCs, therefore to other mobile phones, and to the fixed network.

The BSSs and MSCs are fixed units and can be connected using optic fibre or with conventional electric cables.

Each BSS consists of a Controller, hereinafter referred to with the abbreviation BSC (Base Station Controller), connected to a plurality of transceivers, hereinafter referred to with the abbreviation BTS (Base Transceiver Station), which basically form the terminals of the fixed part of the network which controls communication between mobile phones.

In order to improve the quality of the signal and cover the widest possible areas, the BTSs are placed in strategic positions, in particular in high places, for example on the top of particularly tall buildings.

With the introduction of third generation (UMTS, Universal Mobile Telecommunications System) mobile phones, this is no longer possible, since the structure of the new base stations is much more bulky and heavy and, as a result, much more difficult to handle from a logistics viewpoint. It is easy to imagine how positioning it on a roof, for example, could be extremely problematic.

Therefore, a slight variation of the conventional structure of the BSSs became necessary, disconnecting the BTSs from the antennas and inserting interface units to control the communications traffic between the BTSs and the remote units (RU – the terminals which comprise the antennas for sending/receiving radio frequency signals to/from mobile phones).

The second section of the connection between the BTSs and RUs, from the interface to the RUs, is normally created using optic fibre with significant advantages in terms of the quality of the communication (low attenuation) and the speed of data transmission.

The data exchange between BTSs and RUs must occur in both directions. The data from the BTSs to the RUs and, as a result, to the mobile phones, is the Down-Link (DL), whilst the signals from the mobile phones received by the RUs and sent on to the BTSs are the Up-Link (UL).

Two different wavelengths are normally used for the above-mentioned data exchange, one for the DL and one for the UL.

A typical example of the connection between the base stations and remote units is the so-called "backbone" configuration. An optic fibre cable runs from the interface unit to all of the RUs and ends close to the last RU. Each RU picks up a portion of the signal present in the fibre, selects the DL wavelength, transforms the optical signal into an RF signal and sends it to the mobile phone by means of an antenna. In parallel, if the RU must send data to the BTS, it sends a UL signal at a preset wavelength, different to that of the DL, in the optic fibre.

In this way, there are two data flows supported by the optic fibre, one from the interface unit to the RUs (DL) and one, in the opposite direction to the first, from the RUs to the interface unit (UL).

The UL and DL can be provided using two physically different supports (one fibre for the DL and another fibre for the UL), without significantly altering the structure and operation of the above-mentioned configuration.

The main disadvantage of this type of connection between the BTSs and RUs is the excessive waste of band in order to set up a

bi-directional connection. The connection for each RU uses double the band actually occupied by the signals to be transmitted/received. Too much optic fibre is also used, with significant economic effects on the set up of current systems based on state of the art structures.

Disclosure of the Invention

The aim of the present invention is to provide a new communications network, in particular for telephony, which allows maximum use to be made of the available band when transmitting/receiving signals between operators and remote units.

Another aim of the present invention is to minimise the amount of optic fibre used to create the connection between the operators and the remote units.

In accordance with one aspect of it, the present invention provides a communications network, in particular for telephony, as specified in the independent claim. The dependent claims refer to advantageous preferred embodiments of the invention.

Brief Description of the Drawings

Further features and advantages of the present invention are apparent in the detailed description below, with reference to the accompanying drawings, which illustrate a preferred embodiment of a communications network, in particular for telephony, without limiting the scope of its application, and in which:

Figure 1 is a block diagram of a communications network in accordance with the present invention;

Figure 2 illustrates the structure of some of the blocks in Figure 1;

Figure 3 is a schematic illustration of the structure of a signal processed by the network in Figure 1.

Description of the Illustrative Embodiment

The communications network, in particular for telephony, in accordance with the present invention is labelled with the numeral 1 in the accompanying drawings.

The network 1 basically consists of an operator 2 (a unit controlled by a telecom company, which allows connection to the rest of the telephone network, both mobile and fixed) and a first remote unit 3 and at least a second remote unit 4, which use antennas and suitable circuit equipment to allow signals to be exchanged between the operator 2 and the mobile terminals 5. Between the operator 2 and the remote units 3, 4 there is an interface unit 6, designed to control the data traffic between the operator 2 and the remote units 3, 4.

The network 1 may comprise two or more operators, that is to say, a plurality of blocks controlled by different telephone companies for connection to the rest of the telephone network. In this case, the interface unit 6 controls access to the remote units 3, 4 depending on the requirements of each operator.

Advantageously, each operator 2 communicates with the interface unit 6 by transmission and reception using two carriers, each having a separate physical support.

The interface unit 6 is connected to the remote units 3, 4 using a first transmission support 9, preferably consisting of optic fibre, with at least a first end 10 connected to an interface unit 6 input 7, and at least a second end 11 connected to an interface unit 6 output 8. In this way, the remote units 3, 4 can send/receive signals to/from the interface unit 6 and, as a result, a bi-directional data flow is possible between the remote units 3, 4 and the operator 2.

As illustrated in Figure 1, the interface unit 6 consists of a signal transmission circuit 25 and a signal reception circuit 26.

The signal transmission circuit 25 is positioned at the interface unit 6 output 8 and is connected to the second end 11 of the first transmission support 9. It is basically designed to pick up the signals from the operator 2 and send them to the remote units 3, 4 using the first transmission support 9. The signal transmission circuit 25 is made with a first routing matrix 27, a first electro-optical converter unit 28 and a multiplexer 29. The first routing matrix 27 has at least one input connected to the operator 2 and a plurality of outputs, each connected to a remote unit. The first routing matrix 27 is designed to route the signals

from the operator 2 to the remote units 3, 4 pre-selected by the operator 2.

The electrical signals at the first routing matrix 27 outputs are converted into optical signals by the first electro-optical converter unit 28, so that they can then be sent using an optic fibre support. Finally, the multiplexer 29 downstream of the converters 28, bundles and transfers all optical signals in a single physical support, that is to say, the first transmission support 9.

Therefore, inside the first transmission support 9, a main signal 44 is transmitted, containing all of the data to be sent from the operator 2 to the remote units 3, 4 and vice versa, the data to be sent from the remote units 3, 4 to the operator 2.

Figure 3 shows how the main signal 44, propagating in the first transmission support 9, consists of a plurality of secondary signals 45 identified by a preset parameter value characteristic of the main signal 44. Advantageously, said parameter may be the wavelength and each secondary signal 45 is, therefore, identified by its own wavelength λi, $\lambda i+1$, $\lambda i+2$, etc.

Conveniently, to optimise use of the optic fibre, that is to say, to maximise the number of carriers supported by the fibre, the wave division multiplexing (WDM) technique is used, which consists in sending data along the same fibre, using two or more signals with different wavelengths.

In particular, dense wave division multiplexing (D-WDM) is used, fixing the separation of the signal wavelengths propagating in the optic fibre in the 0.5 - 5 nm range.

Advantageously, semi-dense wave division multiplexing (SD-WDM) can also be used, in which special lasers modulate the signals, which are propagated at the third window of the optic fibre (propagation in an optic fibre occurs in three wavelength ranges, called "windows", the third corresponding to wavelengths of around 1550 nm).

The signal reception circuit 26 is completely symmetrical relative to the signal transmission circuit 25 described above. It has a demultiplexer 30, connected to the first end 10 of the first transmission support 9, to separate the various secondary signals

45 from the remote units 3, 4 sent to the circuits downstream by means of a plurality of outputs. The optical signals from the demultiplexer 30 are then converted into electrical signals by a second electro-optical converter unit 31, then sent to the operator 2 (or operators) by means of a second routing matrix 32.

In light of this, it is obvious how the interface unit 6 is able to control the traffic of signals between the operator 2 (or operators) and the remote units 3, 4.

Figure 2 is a block diagram of a single remote unit. It comprises a signal transmission block 12, connected to the first transmission support 9 to pick up at least one secondary signal 45a from the main signal 44 (the secondary signals 45 are then sent to the mobile terminals 5 by means of an antenna 14) and a signal reception block 13, which receives the RF signals from the mobile terminals 5 by means of the antenna 14 and adds them to the main signal 44 in the first transmission support 9.

Conveniently, the signal transmission block 12 is made using an optical filter element 15 to pick up at least one secondary signal 45a from the main signal 44, a first electro-optical converter 17 to transform the secondary signal 45a into an electrical signal, a first amplifier block 18 and a first RF filter 19 to treat the electrical signal before transmitting it in radio frequency to the mobile terminals 5 by means of the antenna 14.

Similarly, the signal reception block 13 comprises a second RF filter 20 and a second amplifier block 21 for treating the RF signals arriving from the mobile terminals 5 and received by the antenna 14, a second electro-optical converter 22 to transform the electrical signals into optical signals and a signal reception element 26 connected to the first transmission support 9 to add the contributions received from the mobile terminals 5 to the main signal 44.

Advantageously, to equalise the secondary signal 45a and prepare it for subsequent processing, the signal transmission block 12 has a first equaliser block 16 downstream of the optical filter element 15 and the signal reception block 13 has a second

equaliser block 23 downstream of the second electro-optical converter 22.

The first transmission support 9 is made substantially in the form of an optic fibre loop which terminates at the interface unit 6 and passes through all of the remote units 3, 4 once. The first remote unit 3 has a first input 33 directly connected to the output 8 of the interface unit 6 and a first output 34 connected to a first input 35 of the second remote unit 4. The latter has a first output 36 directly connected to the input 7 of the interface unit 6.

Similarly, each remote unit is associated with at least one wavelength λi. If necessary a plurality of wavelengths λi, $\lambda i+1$, etc. can be associated with a single remote unit.

In this way, when the operator 2 wants to send a signal to a given remote unit so that it will be transmitted to a mobile terminal 5, it uses the first routing matrix 27 and the first electro-optical converter unit 28 to shift the signal to the wavelength λi associated with the selected remote unit and the signal is introduced into the first transmission support 9 by the multiplexer 29.

Using the circuit equipment described above, the selected remote unit selects, within the main signal 44, the secondary signal 45a at the wavelength λi associated with the remote unit, converts it to RF and sends it to the mobile terminal 5 to which the signal is directed.

When the remote unit receives signals from the mobile terminal 5 which must be sent to the operator 2, it shifts them to its characteristic wavelength λi and inserts them into the main signal 44, so that at the end of propagation in the first transmission support 9, they reach the input of the interface unit 6 and, from here, are sent to the operator 2.

With a structure such as that described above, each remote unit is, therefore, associated with a wavelength λi on which it dialogs in both directions with the interface unit 6 and, therefore, with the operator 2.

The fact that the optic fibre support substantially assumes the form of a loop closed on the interface unit 6 allows the main

signal 44 to be sent from the interface unit 6 output 8, to go through all of the remote units 3, 4 (transmitting to and receiving from them any signals at the preset wavelength λi) and to reach the interface unit 6 input 7, carrying all of the data gathered from the remote units 3, 4.

Advantageously, the network 1 may have a second transmission support 41, again made of optic fibre and having the twin purposes of making the system more reliable and improving the quality of reception and transmission of the mobile units 3, 4 and the interface unit 6.

As explained in greater detail below, another advantage of the second transmission support 41 is that the communications network 1 created is also resilient.

The second transmission support 41 is an optic fibre loop with a first end 42 connected to the interface unit 6 input and a second end 43 connected to the interface unit 6 output 8. Inside the second transmission support 41, an auxiliary signal 46 substantially equal to the main signal 44 is propagated.

The second transmission support 41 passes through all of the remote units 3, 4 once, so that the auxiliary signal 46 reaches the remote units 3, 4 in the opposite order to the main signal 44 propagated in the first transmission support 9. The second remote unit 4 has a second input 39 directly connected to the interface unit 6 output by means of the second transmission support 41 and an output connected to a second input 37 of the first remote unit 3 by means of the second transmission support 41. The first remote unit 3 has a second output 38 directly connected to the interface unit 6 input by means of the second transmission support 41.

The auxiliary signal 46 is a replica of the main signal 44 and is propagated in the second transmission support 41.

In this way, by supplying the remote units 3, 4 with the same data by means of two separate physical supports, there are significant advantages in terms of the quality of the communication. If, for example, the first transmission support 9 develops a fault, thanks to the second transmission support 41 there would be no need to interrupt the connection between the remote units 3, 4 and the interface unit 6.

Moreover, by constantly using both transmission supports 9, 41, so that the two identical signals 44, 46 are constantly supplied to each remote unit 3, 4 by means of independent supports, the probability of reception/transmission errors is reduced, that is to say, it becomes extremely unlikely that part of the data will be lost or altered as it travels between the interface unit 6 and the remote units 3, 4.

Use of the second transmission support 41 may be controlled in various ways. The auxiliary signal 46 may be propagated only if a fault develops in the first transmission support 9, or it may be constantly propagated parallel with the propagation of the main signal 44 in the first transmission support 9, to reduce the probability of error as indicated above.

If more than two remote units are required, a third remote unit may, for example, be positioned between the first remote unit 3 and the second remote unit 4.

The third remote unit would have a first input, connected to the first output 34 of the first remote unit 3 by the first transmission support 9, and a first output connected to the first input 35 of the second remote unit 4. The third remote unit would also have a second input, connected to the second output 40 of the second remote unit 4 by the second transmission support 41, and a second output, connected to the second input 37 of the first remote unit 3.

The present invention brings important advantages.

First, an entire communications network made in accordance with the present invention is extremely economical to set up, since the optic fibre used is minimised.

Moreover, it is very efficient in terms of band use, since the same wavelength λi is used both for the DL and the UL between the interface unit and the remote units.

Another advantage is the fact that, thanks to the versatility of the routing matrices, the network is very flexible and can be adapted to various requirements when setting up the connections between the operators and the remote units.

Finally, the introduction of a second loop, parallel with and propagating in the opposite direction to the first, allows the

creation of a communications network which is resilient and characterised by the high quality of the connection between the operators and the remote units.

The invention described can be subject to modifications and variations without thereby departing from the scope of the inventive concept. Moreover, all the details of the invention may be substituted by technically equivalent elements.

Claims

1. A communications network, in particular for telephony, characterised in that it comprises:

at least one operator (2);

a plurality of remote units (3, 4) designed to exchange signals with the operator (2) and to exchange radio frequency (RF) signals with mobile terminals (5);

an interface unit (6) inserted between the operator (2) and the remote units (3, 4), the interface unit (6) having at least one input (7) for receiving signals from the remote units (3, 4) and at least one output (8) for sending signals to the remote units (3, 4), the interface unit (6) also being designed to exchange signals with the operator (2);

a first transmission support (9) for connecting the interface unit (6) to the remote units (3, 4), the first transmission support (9) being designed to support a main signal (44), the first transmission support (9) having a first end (10) connected to the interface unit (6) input (7) and at least a second end (11) connected to the interface unit (6) output (8), the main signal (44) consisting of a plurality of secondary signals (45), each identified by a preset parameter value, each of the remote units (3, 4) being designed to process a secondary signal (45a) intended for it, each of the remote units (3, 4) being able to select at least one secondary signal (45a) intended for it according to the preset parameter value.

2. The network according to claim 1, characterised in that the preset parameter is a wavelength, the remote units (3, 4) sending to and receiving from the interface unit (6) signals at the wavelength (λi) associated with them.

3. The network according to claim 1 or 2, characterised in that the secondary signals (45) received from and sent to the interface unit (6) by the remote units (3, 4) are bundled and preferably multiplexed by the interface unit (6) according to the dense wave division multiplexing (D-WDM) technique, in particular according to the semi-dense wave division multiplexing (SD-WDM) technique.

4. The network according to claim 1 or 2, characterised in that the first transmission support (9) comprises an optic fibre support, the main signal (44) being an optical signal propagating from the second end (11) to the first end (10).

5. The network according to any of the foregoing claims, characterised in that each remote unit comprises:

a signal transmission block (12) connected to the first transmission support (9) for picking up at least one secondary signal (45a) from the main signal (44) to be transmitted in the DL;

a signal reception block (13) connected to the first transmission support (9) for adding at least one signal received in the UL to the main signal (44);

an antenna (14) attached to the signal transmission block (12) and to the signal reception block (13) for transmitting RF signals to the mobile terminals (5) and for receiving RF signals from the mobile terminals (5).

6. The network according to claim 5, characterised in that the signal transmission block (12) comprises:

an optical filter element (15) connected to the first transmission support (9) for selecting, within the main signal (44), the secondary signal (45a) characterised by the parameter value associated with the remote unit;

preferably a first equaliser block (16) connected downstream of the optical filter element (15);

a first electro-optical converter (17), for converting the optical signal from the interface unit (6) into an electrical signal;

a first amplifier block (18) connected to the first electro-optical converter (17);

a first RF filter (19) for filtering the signals from the first converter.

7. The network according to claim 5 or 6, characterised in that the signal reception block (13) comprises:

a second RF filter (20) for filtering a signal from the antenna (14);

a second amplifier block (21) connected to the second RF filter (20);

a second electro-optical converter (22) for converting an electrical signal from the second RF filter (20) into an optical signal;

preferably, a second equaliser block (23) connected downstream of the second electro-optical converter (22);

a signal insertion element (24) for adding a signal received, characterised by the preset parameter value associated with the remote unit, to the main signal (44).

8. The network according to any of the foregoing claims, characterised in that the interface unit (6) comprises:

a signal transmission circuit (25) connected to the output (8) and connected to the second end (11) of the first transmission support (9), the signal transmission circuit (25) picking up signals from the operator (2) and sending them to the remote units (3, 4);

a signal reception circuit (26) connected to the input (7) and connected to the first end (10) of the first transmission support (9), the signal reception circuit (26) receiving signals from the remote units (3, 4) and transmitting them to the operator (2).

9. The network according to claim 8, characterised in that the signal transmission circuit (25) comprises:

a first routing matrix (27) with at least one input connected to the operator (2) for receiving a signal from the operator (2) and two or more outputs for sending electrical signals;

a first electro-optical converter unit (28) connected to the outputs of the first routing matrix (27), for transforming the electrical signals from the first routing matrix (27) into optical signals;

a multiplexer (29) between the first electro-optical converter unit (28) and the second end (11) of the first transmission support (9), for bundling and transferring the optical signals from the first electro-optical converter unit (28) in the first transmission support (9).

10. The network according to claim 8 or 9, characterised in that the signal reception circuit (26) comprises:

a demultiplexer (30) connected to the first end (10) of the first transmission support (9), for receiving the main signal (44) and having a plurality of outputs for sending optical signals;

a second electro-optical converter unit (31) connected to the outputs of the demultiplexer (30) for transforming the optical signals sent by the demultiplexer (30) into electrical signals;

a second routing matrix (32) with two or more inputs connected to the second electro-optical converter unit (31) and at least one output connected to the operator (2).

11. The network according to any of the foregoing claims, comprising:

at least one operator (2);

a first remote unit (3) and at least a second remote unit (4), the remote units (3, 4) being designed to exchange signals with the operator (2) and to exchange radio frequency (RF) signals with the mobile terminals;

an interface unit (6) inserted between the operator (2) and the remote units (3, 4), the interface unit (6) having at least one input (7) for receiving signals from the remote units (3, 4) and at least one output (8) for sending signals to the remote units (3, 4), the interface unit (6) also being designed to exchange signals with the operator (2);

a first transmission support (9) for connecting the interface unit (6) to the remote units (3, 4), the first transmission support (9) being designed to support a main signal (44), the first transmission support (9) having a first end (10) connected to the interface unit (6) input (7) and at least a second end (11) connected to the interface unit (6) output (8), the network being characterised in that the first remote unit (3) has a first input (33) directly connected to the interface unit (6) output (8) by the first transmission support (9) and a first output (34), the second remote unit (4) having a first input (35) connected to the first output (34) of the first remote unit (3) by the first transmission support (9) and a first output (36) directly connected to the interface unit (6) input (7) by the first transmission support (9), the main signal (44) propagating in the

first transmission support (9) from the second end (11) to the first end (10).

12. The network according to claim 11, characterised in that the first transmission support (9) basically consists of an optic fibre loop passing through each remote unit, the main signal (44) being an optical signal propagating in the loop from the first remote unit (3) to the second remote unit (4).

13. The network according to claim 12, characterised in that it also comprises a second transmission support (41), having a first end (42) connected to the interface unit (6) input (7) and a second end (43) connected to the interface unit (6) output (8), for supporting an auxiliary signal (46) substantially identical to the main signal (44), the auxiliary signal (46) propagating in the second transmission support (41) from the second end (43) of the second transmission support (41) to the first end (42) of the second transmission support (41).

14. The network according to claim 13, characterised in that the second remote unit (4) has a second input (39) directly connected to the interface unit (6) output (8) by the second transmission support (41) and a second output (40), the first remote unit (3) having a second input (37) connected to the second output (40) of the second remote unit (4) by the second transmission support (41) and a second output (38) directly connected to the interface unit (6) input (7) by the second transmission support (41), the auxiliary signal (46) propagating in the second transmission support (41) from the second remote unit (4) to the first remote unit (3).

15. The network according to claim 14, characterised in that the second transmission support (41) basically consists of an optic fibre loop which passes through each of the remote units, the auxiliary signal (46) being an optical signal propagating in the second transmission support (41) from the second remote unit (4) to the first remote unit (3).

16. The network according to any of the foregoing claims, characterised in that it also comprises a plurality of operators which can be connected to the remote units (3, 4) by means of the interface unit (6).

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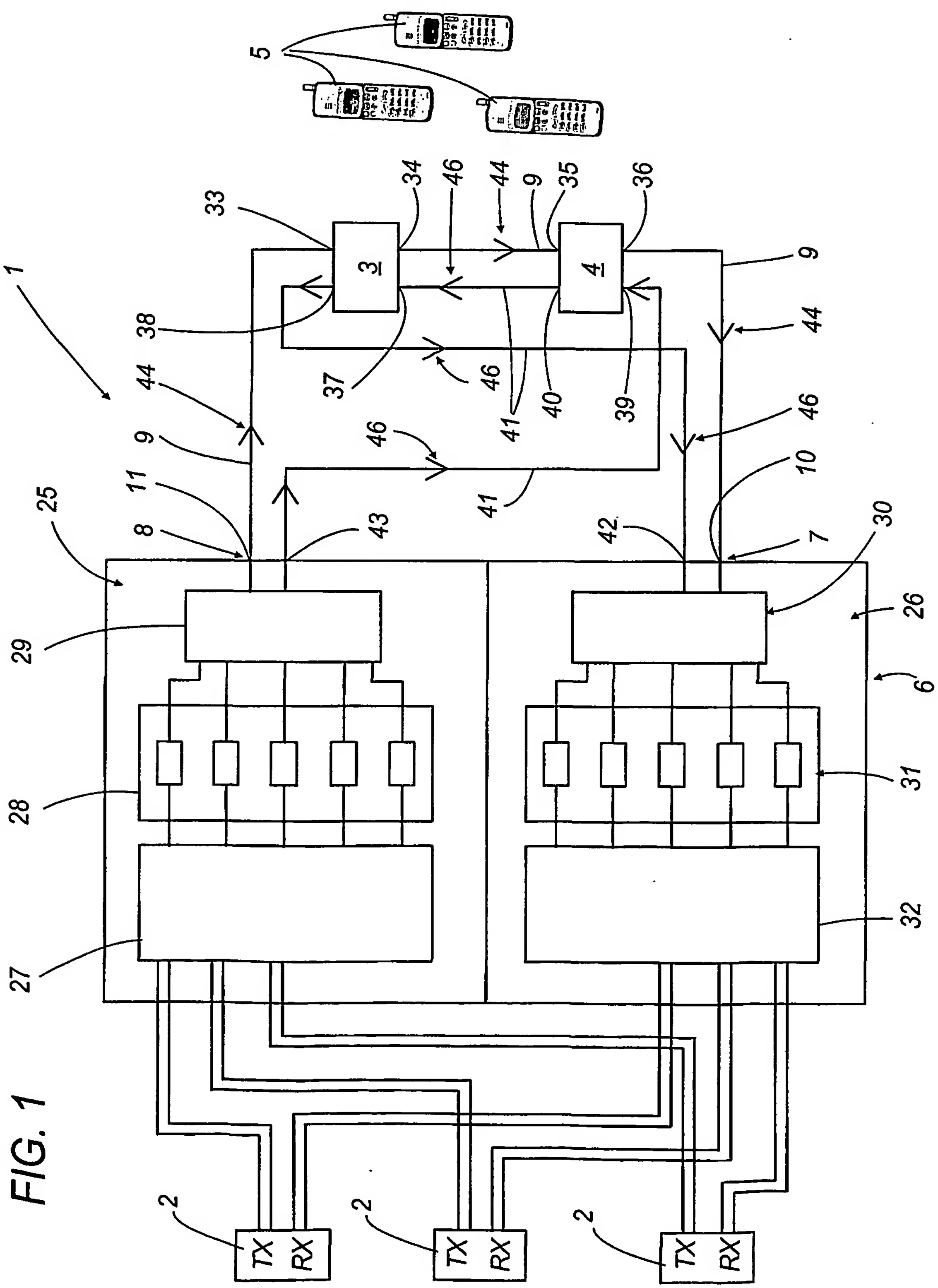


FIG. 1

FIG. 2

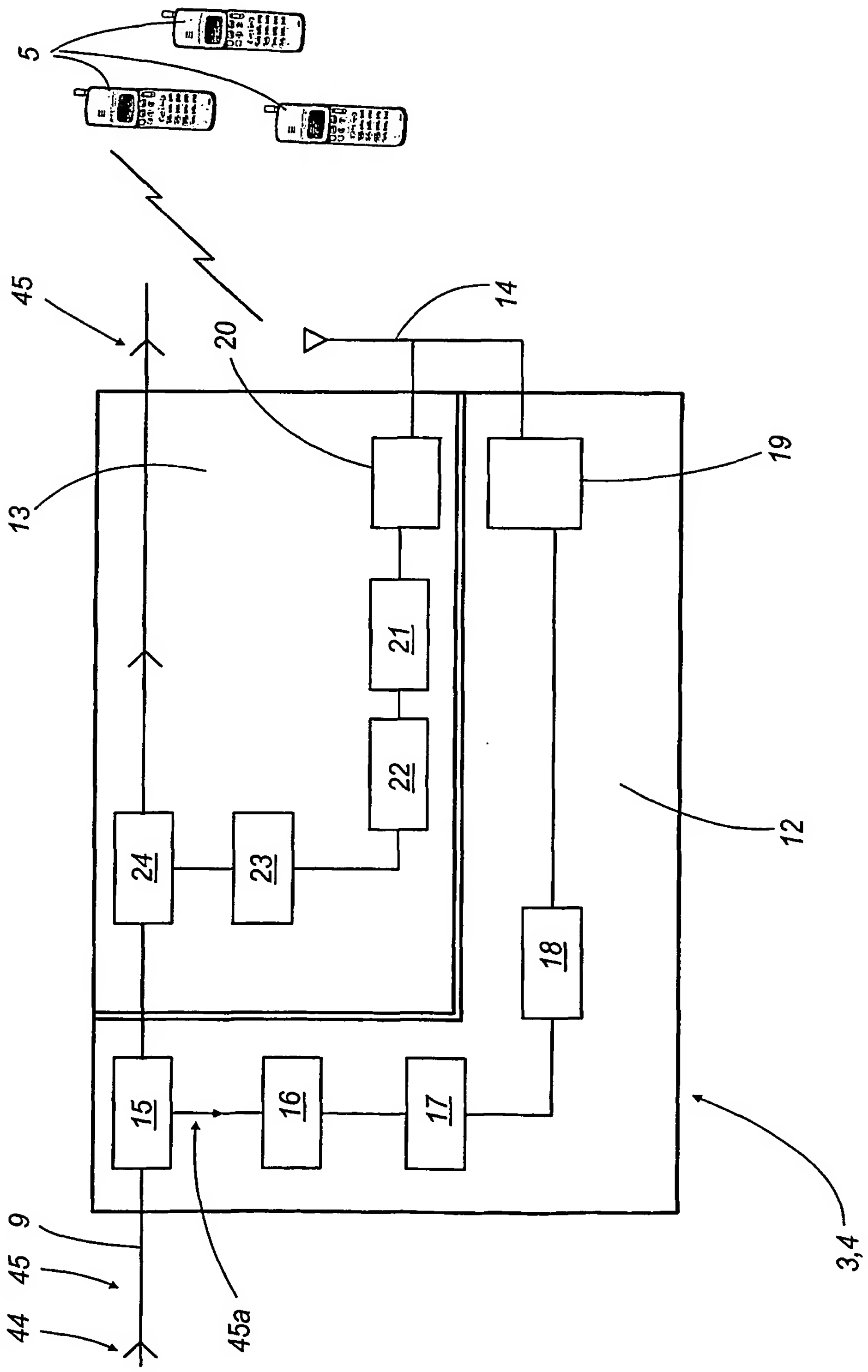
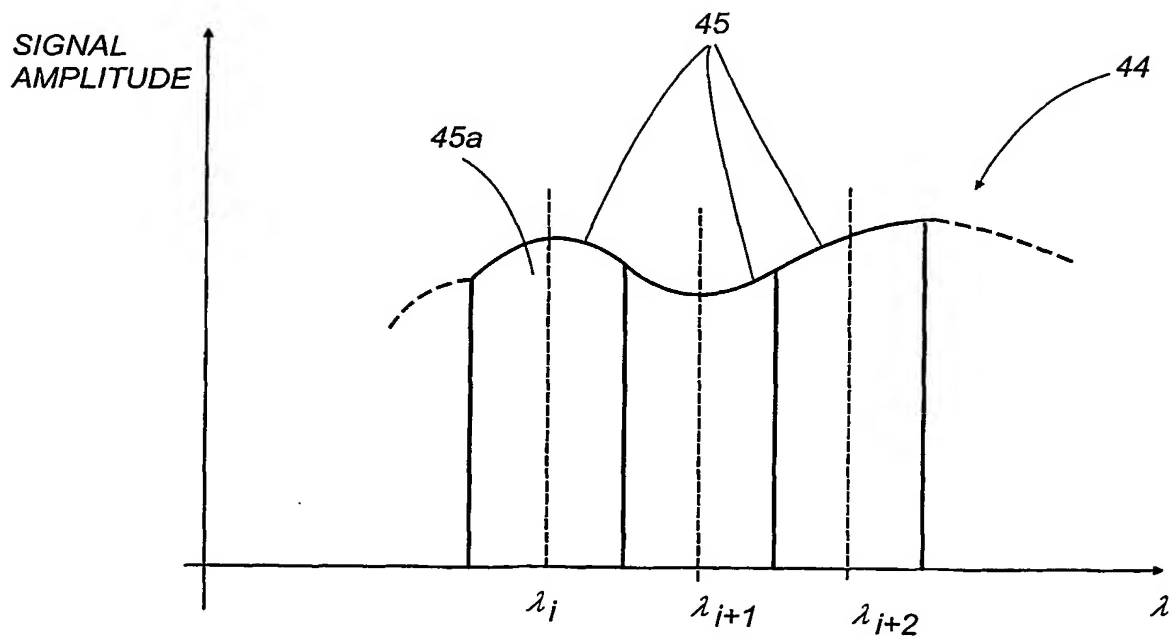


FIG. 3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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 01/02040

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 339 184 A (TANG DOUGLAS D) 16 August 1994 (1994-08-16) abstract column 2, line 61 -column 4, line 60 figures 2,3A,3B,4A,4B ---	1 2-16
X Y	SAUER M ET AL: "RF-FRONT END AND OPTICAL FEEDING SYSTEM FOR A MILLIMETER-WAVE BROADBAND COMMUNICATIONS SYSTEM AT 60 GHZ" SBMO/IEEE MTT-S. INTERNATIONAL MICROWAVE AND OPTOELECTRONICS CONFERENCE, XX, XX, 1997, pages 227-232, XP000764638 page 227, line 23 -page 229, line 29 figures 1,2 --- -/--	1 2-16

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 March 2002	02/04/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Rabe, M

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 16054 A (MVS INC) 16 April 1998 (1998-04-16) abstract page 7, line 6 -page 10, line 19 figure 1 ---	1-16
A	US 5 969 837 A (LOBODA HOWARD ET AL) 19 October 1999 (1999-10-19) abstract column 3, line 52 -column 4, line 40 figures 2,3 ---	1-16
A	SHANKARANARAYANAN N K ET AL: "Multiport wireless access system using fiber/coax networks for personal communications services (PCS) and subscriber loop applications" GLOBAL TELECOMMUNICATIONS CONFERENCE, 1995. CONFERENCE RECORD. COMMUNICATION THEORY MINI-CONFERENCE, GLOBECOM '95., IEEE SINGAPORE 13-17 NOV. 1995, NEW YORK, NY, USA,IEEE, US, 13 November 1995 (1995-11-13), pages 977-981, XP010164519 ISBN: 0-7803-2509-5 page 979, left-hand column, line 19 -right-hand column, line 10 figure 2 -----	1-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 01/02040

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5339184 A	16-08-1994	NONE	
WO 9816054 A	16-04-1998	US 6016426 A	18-01-2000
		EP 0944990 A1	29-09-1999
		WO 9816054 A1	16-04-1998
		US 6324391 B1	27-11-2001
US 5969837 A	19-10-1999	AU 735820 B2	19-07-2001
		AU 5408298 A	15-07-1998
		BR 9713714 A	13-06-2000
		EP 0950326 A2	20-10-1999
		WO 9827748 A2	25-06-1998
		JP 2001506826 T	22-05-2001

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PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70) 10/088123

Applicant's or agent's file reference 61.T3315.W03	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/IB01/02040	International filing date (*day/month/year*) 30/10/2001	Priority date (*day/month/year*) 31/10/2000
International Patent Classification (IPC) or national classification and IPC H04Q7/30		
Applicant TEKMAR SISTEMI S.r.L.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of nine sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

MAR 10 2003

Date of submission of the demand 29/05/2002	Date of completion of this report 23.12.2002
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Rabe, M Telephone No. +49 89 2399 8801

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, pages:

1,3-9	as originally filed			
2,2bis,2ter,10	as received on	08/10/2002	with letter of	03/10/2002

Claims, No.:

15,16	as originally filed			
1-14	as received on	08/10/2002	with letter of	03/10/2002

Drawings, sheets:

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:
   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-14
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-14
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-14
	No:	Claims	

2. Citations and explanations
   see separate sheet

Reference is made to the following documents:

D1: US-A-5 339 184

D2: 'RF-FRONT END AND OPTICAL FEEDING SYSTEM FOR A MILLIMETER-WAVE BROADBAND COMMUNICATIONS SYSTEM AT 60 GHZ' SBMO/IEEE MTT-S. INTERNATIONAL MICROWAVE AND OPTOELECTRONICS CONFERENCE, XX, XX, 1997, pages 227-232; SAUER M ET AL.

A. Citations and explanations made in respect of paragraph V:

1. The present invention relates to a **communications network** according to the features of the preamble of **claim 1.**

2. **Generally**, in **present** cellular communications networks, mobile terminals dialog by means of radio frequencies with base station systems, each consisting of a base station controller (BSC) connected to a plurality of base transceiver stations (BTS), wherein the BTSs are placed in strategic positions o improve the quality of the transmission signals and to cover the widest possible areas. With the introduction of the third generation mobile communications systems (UMTS), the structure of BSSs has been changed by inserting interface units between the BTSs and remote units, wherein the remote units comprise the antennas for sending/receiving signals to/from the mobile terminals.

   Document **D1** describes such a communications network, wherein a BTS is connected via an interface unit to a plurality of remote units. The BTS and the interface unit are coupled by way of two optical fibres (one for each of the uplink and downlink), and each of the remote units is associated with a corresponding electrical path for bi-directional connection with the interface unit.

   Furthermore, document **D2** discloses a backbone configuration for connecting the BTS/interface unit to a plurality of remote units, wherein the backbone comprises a loop of two different and distinct optical fibres, respectively for the uplink and downlink communication between the remote units and the BTS/interface unit. Each remote unit is connected to the backbone by way of an add-drop-multiplexer

for selecting, based on preset parameters, a secondary signal intended for it from the main signal propagating on the optical fibre loop.

3. A main **disadvantage** related to the above communications networks is that separate optical fibres are used for the uplink and downlink transmissions between the interface unit and the remote units, thereby requiring a high amount of optical fibre employed and a corresponding high number of optical amplifiers for generating the signals on the fibres.

4. The **present invention** overcomes these disadvantages by providing a communications network according to the characterizing features of **claim 1**.

   According to the **essential features of the invention**, the input of a first remote unit is directly connected to the output of the interface unit by a transmission support, the input of a second remote unit is connected to the output of the first remote unit by the transmission support, and the output of the second remote unit is connected to the input of the interface unit by the transmission support, wherein the transmission support consists of an optical fibre loop passing through each remote unit.

5. The present invention provides, by the use of an optical path comprising only one optical fibre closed on the interface unit, the **advantage** of minimizing the amount of optical fibre employed and of decreasing the amount of optical amplifiers used.

6. The subject-matter of the present invention as claimed in claim 1 is neither disclosed in, nor rendered obvious by the remaining **prior art documents** cited in the international search report since said documents, which merely relate to a very general state of the art of communications networks including optical connections between the a BSS and plural remote units, do **not** describe or render (in combination) obvious the communications network according to the particular feature combination of the present invention or part thereof as defined in claim 1.

7. The subject-matter of claim 1 therefore is considered to be **new** and to **involve an inventive step**, Article 33 (2) and (3) PCT.

8. As **claims 2 to 14** are dependent on claim 1, said claims 2 to 14 do **also meet** the requirements of Article 33 (2) and (3) PCT.

9. The present invention is **susceptible of industrial application**, Article 33 (4) PCT.

B. Other remarks made in respect of the present application:

1. The following amendment would have been necessary to the **description**:

   On page 2-ter of the description, the prior art document should have been correctly cited as 'RF-FRONT END AND OPTICAL FEEDING SYSTEM FOR A MILLIMETER-WAVE BROADBAND COMMUNICATIONS SYSTEM AT 60 GHZ', by Sauer M. et al.; **SBMO/IEEE MTT-S. INTERNATIONAL MICROWAVE AND OPTOELECTRONICS CONFER-ENCE, XX, XX, 1997, pages 227-232.**

2. The following amendment would have been necessary to the **claims**:

   The features "**said** first remote units" and "**the** second remote unit" in respective lines 1 and 4 of the characterizing portion of **claim 1** are not clear, Article 6 PCT, since said features have not been previously defined in said claim, ie. said features have **no** antecedent. A corresponding amendment by replacing each of "said" and "the" by "**a**" would have been necessary.

Therefore, a slight variation of the conventional structure of the BSSs became necessary, disconnecting the BTSs from the antennas and inserting interface units to control the communications traffic between the BTSs and the remote units (RU – the terminals which comprise the antennas for sending/receiving radio frequency signals to/from mobile phones).

The second section of the connection between the BTSs and RUs, from the interface to the RUs, is normally created using optic fibre with significant advantages in terms of the quality of the communication (low attenuation) and the speed of data transmission.

The data exchange between BTSs and RUs must occur in both directions. The data from the BTSs to the RUs and, as a result, to the mobile phones, is the Down-Link (DL), whilst the signals from the mobile phones received by the RUs and sent on to the BTSs are the Up-Link (UL). <INSERT PAGE 2-bis>

Two different wavelengths are normally used for the above-mentioned data exchange, one for the DL and one for the UL.

A typical example of the connection between the base stations and remote units is the so-called "backbone" configuration. An optic fibre cable runs from the interface unit to all of the RUs and ends close to the last RU. Each RU picks up a portion of the signal present in the fibre, selects the DL wavelength, transforms the optical signal into an RF signal and sends it to the mobile phone by means of an antenna. In parallel, if the RU must send data to the BTS, it sends a UL signal at a preset wavelength, different to that of the DL, in the optic fibre.

In this way, there are two data flows supported by the optic fibre, one from the interface unit to the RUs (DL) and one, in the opposite direction to the first, from the RUs to the interface unit (UL).

The UL and DL can be provided using two physically different supports (one fibre for the DL and another fibre for the UL), without significantly altering the structure and operation of the above-mentioned configuration. <INSERT PAGE 2-Ter>

The main disadvantage of this type of connection between the BTSs and RUs is the excessive waste of band in order to set up a

Document US 5,339,189 relates to a cellular communications system, in which a base station is connected to a plurality of remote cellular units by a communications link, having a base terminal coupled to a remote terminal by two optical fibres.

The base terminal receives RF downlink channels from the base station and optically transmits said signals as a non-overlapping composite signal to the remote terminal on a first fiber. The RF downlink channels are individually recovered at the remote terminal and distributed to designated remote units.

The remote terminal also functions to receive RF uplink channels from the remote units and optically transmit the RF channels as a non-overlapping composite signal to the base terminal on a second fiber. The RF uplink channels are individually recovered at the base terminal and forwarded to the base station.

An example of a "backbone" configuration using two different optic fiber supports for the uplink transmission and the downlink transmission is disclosed in the scientific publication "RF-FRONT END AND OPTICAL FEEDING SYSTEM FOR A MILLIMETER-WAVE BROADBAND COMMUNICATIONS SYSTEM AT 60GHZ"*, by Sauer M. et al.; in particular, in paragraph II and figure 1 a telecommunications system is shown, in which each remote unit is associated with a corresponding wavelength and, by means of suitable add-drop-multiplexers, is able to select said wavelength and add and/or drop signals into/from the optic fiber support.*

creation of a communications network which is resilient and characterised by the high quality of the connection between the operators and the remote units.

~~The invention described can be subject to modifications and variations without thereby departing from the scope of the inventive concept. Moreover, all the details of the invention may be substituted by technically equivalent elements.~~

Claims

1. A communications network, in particular for telephony, ~~characterised in that it comprises~~ COMPRISING:

at least one operator (2);

a plurality of remote units (3, 4) designed to exchange signals with the operator (2) and to exchange radio frequency (RF) signals with mobile terminals (5);

an interface unit (6) inserted between the operator (2) and the remote units (3, 4), the interface unit (6) having at least one input (7) for receiving signals from the remote units (3, 4) and at least one output (8) for sending signals to the remote units (3, 4), the interface unit (6) also being designed to exchange signals with the operator (2);

a first transmission support (9) for connecting the interface unit (6) to the remote units (3, 4), the first transmission support (9) being designed to support a main signal (44), the first transmission support (9) having a first end (10) connected to the interface unit (6) input (7) and at least a second end (11) connected to the interface unit (6) output (8), the main signal (44) consisting of a plurality of secondary signals (45), each identified by a preset parameter value, each of the remote units (3, 4) being designed to process a secondary signal (45a) intended for it, each of the remote units (3, 4) being able to select at least one secondary signal (45a) intended for it according to the preset parameter value, <INSERT PAGE 11-bis>

2. The network according to claim 1, characterised in that the preset parameter is a wavelength, the remote units (3, 4) sending to and receiving from the interface unit (6) signals at the wavelength (λi) associated with them.

3. The network according to claim 1 or 2, characterised in that the secondary signals (45) received from and sent to the interface unit (6) by the remote units (3, 4) are bundled and preferably multiplexed by the interface unit (6) according to the dense wave division multiplexing (D-WDM) technique, in particular according to the semi-dense wave division multiplexing (SD-WDM) technique.

the network being characterised in that said first remote unit (3) has a first input (33) directly connected to the interface unit (6) output (8) by the first transmission support (9) and a first output (34), the second remote unit (4) having a first input (35) connected to the first output (34) of the first remote unit (3) by the first transmission support (9) and a first output (36) directly connected to the interface unit (6) input (7) by the first transmission support (9), the main signal (44) propagating in the first transmission support (9) from the second end (11) to the first end (10), the first transmission support (9) basically consisting of an optic fibre loop passing through each remote unit, the main signal (44) being an optical signal propagating in the loop from the first remote unit (3) to the second remote unit (4).

4. The network according to claim 1 or 2, characterised in that the first transmission support (9) comprises an optic fibre support, the main signal (44) being an optical signal propagating from the second end (11) to the first end (10).

5. The network according to any of the foregoing claims, characterised in that each remote unit comprises:

a signal transmission block (12) connected to the first transmission support (9) for picking up at least one secondary signal (45a) from the main signal (44) to be transmitted in the ~~DL~~ DOWNLINK;

a signal reception block (13) connected to the first transmission support (9) for adding at least one signal received in the ~~UL~~ UPLINK to the main signal (44);

an antenna (14) attached to the signal transmission block (12) and to the signal reception block (13) for transmitting RF signals to the mobile terminals (5) and for receiving RF signals from the mobile terminals (5).

6. The network according to claim 5, characterised in that the signal transmission block (12) comprises:

an optical filter element (15) connected to the first transmission support (9) for selecting, within the main signal (44), the secondary signal (45a) characterised by the parameter value associated with the remote unit;

preferably a first equaliser block (16) connected downstream of the optical filter element (15);

a first electro-optical converter (17), for converting the optical signal from the interface unit (6) into an electrical signal;

a first amplifier block (18) connected to the first electro-optical converter (17);

a first RF filter (19) for filtering the signals from the first converter.

7. The network according to claim 5 or 6, characterised in that the signal reception block (13) comprises:

a second RF filter (20) for filtering a signal from the antenna (14);

a demultiplexer (30) connected to the first end (10) of the first transmission support (9), for receiving the main signal (44) and having a plurality of outputs for sending optical signals;

a second electro-optical converter unit (31) connected to the outputs of the demultiplexer (30) for transforming the optical signals sent by the demultiplexer (30) into electrical signals;

a second routing matrix (32) with two or more inputs connected to the second electro-optical converter unit (31) and at least one output connected to the operator (2).

~~11. The network according to any of the foregoing claims,~~ comprising:

at least one operator (2);

a first remote unit (3) and at least a second remote unit (4), the remote units (3, 4) being designed to exchange signals with the operator (2) and to exchange radio frequency (RF) signals with the mobile terminals;

an interface unit (6) inserted between the operator (2) and the remote units (3, 4), the interface unit (6) having at least one input (7) for receiving signals from the remote units (3, 4) and at least one output (8) for sending signals to the remote units (3, 4), the interface unit (6) also being designed to exchange signals with the operator (2);

a first transmission support (9) for connecting the interface unit (6) to the remote units (3, 4), the first transmission support (9) being designed to support a main signal (44), the first transmission support (9) having a first end (10) connected to the interface unit (6) input (7) and at least a second end (11) connected to the interface unit (6) output (8), the network being characterised in that the first remote unit (3) has a first input (33) directly connected to the interface unit (6) output (8) by the first transmission support (9) and a first output (34), the second remote unit (4) having a first input (35) connected to the first output (34) of the first remote unit (3) by the first transmission support (9) and a first output (36) directly connected to the interface unit (6) input (7) by the first transmission support (9), the main signal (44) propagating in the~~transmission support (9), the main signal (44) propagating in the~~

~~first transmission support (9) from the second end (11) to the~~ first end (10).

12. The network according to claim 11, characterised in that the first transmission support (9) basically consists of an optic fibre loop passing through each remote unit, the main signal (44) being an optical signal propagating in the loop from the first ~~remote unit (3) to the second remote unit (4).~~

11 ~~13.~~ The network according to claim 1 ~~12,~~ characterised in that it also comprises a second transmission support (41), having a first end (42) connected to the interface unit (6) input (7) and a second end (43) connected to the interface unit (6) output (8), for supporting an auxiliary signal (46) substantially identical to the main signal (44), the auxiliary signal (46) propagating in the second transmission support (41) from the second end (43) of the second transmission support (41) to the first end (42) of the second transmission support (41).

12 ~~14.~~ The network according to claim 11 ~~13,~~ characterised in that the second remote unit (4) has a second input (39) directly connected to the interface unit (6) output (8) by the second transmission support (41) and a second output (40), the first remote unit (3) having a second input (37) connected to the second output (40) of the second remote unit (4) by the second transmission support (41) and a second output (38) directly connected to the interface unit (6) input (7) by the second transmission support (41), the auxiliary signal (46) propagating in the second transmission support (41) from the second remote unit (4) to the first remote unit (3).

13 ~~15.~~ The network according to claim 12 ~~14,~~ characterised in that the second transmission support (41) basically consists of an optic fibre loop which passes through each of the remote units, the auxiliary signal (46) being an optical signal propagating in the second transmission support (41) from the second remote unit (4) to the first remote unit (3).

14 ~~16.~~ The network according to any of the foregoing claims, characterised in that it also comprises a plurality of operators which can be connected to the remote units (3, 4) by means of the interface unit (6).